DIET DIVERSITY WHILE INTRODUCING SOLIDS TO BREASTFED INFANTS AND THE EFFECT ON THEIR GROWTH

By

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Abstract:
The purpose of this study was to evaluate the growth of predominantly breastfed babies at six and nine months of age and determine how this was related to diet diversity and parenting stress. This study was part of a larger study examining the relationship between maternal levels of micronutrients and infant cognitive development that was conducted between 2008 and 2010. 132 mother and infant pairs from Oklahoma, in which the infants were predominantly breastfeeding at the age of three months participated in the large study, while 120 of those pairs were selected to use in the current study.

The infants had clinical visits at three, six and nine months of age where anthropometric measurements were taken. At three months, an assessment of how much breast milk was consumed in a 24-hour period was done, by measuring the infants' before and after feeding weights. Also, the mother filled out The Parenting Stress Index (PSI), short form. At six and nine months the mother filled out the infant dietary questions to determine what foods the infant was consuming at that time period and to calculate the infants' diet diversity score.

Descriptive statistics showed that over 30 percent of infants were introduced to solid foods after their six-month visit. At six months over 70 percent of infants had diet diversity scores below four and at nine months 15 percent of infants had a diet diversity score below four. Over 80 percent of the infants were not receiving any supplements at either six or nine months. Lastly, at six months 23 infants were not being fed solids two to three times per day and at nine months 43 infants were not being fed three to four times per day. It was determined there were no significant relations between diet diversity and the anthropometric measurements or parenting stress.

It was determined that many infants were not being adequately fed in relation to the timing of solid food introduction, frequency of meals each day, diet diversity, and supplement intake.

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CHAPTER I

Introduction

Breastfeeding Recommendations.

The current recommendation from the American Academy of Pediatrics (AAP) is to exclusively breastfeed infants for the first six months of life (American Academy of Pediatrics [AAP], 2012). This recommendation coincides with those of the World Health Organization (WHO) and the Academy of Nutrition and Dietetics (AND) (Academy of Nutrition and Dietetics [AND], 2012A; World Health Organization [WHO], 2013). The United States has goals to increase the number of infants who are ever breastfed and who are exclusively breastfed set forth by Healthy People 2020 (U.S. Department of Health and Human Services, 2013).

Breastfeeding provides multiple beneficial nutrients to the infant during the first year of life, but due to exclusive breastfeeding, some infants may be lacking a few nutrients, especially if parents are unaware of supplement recommendations. In 2008, the AAP increased the recommended supplement of Vitamin D for breastfed infants from 200 IU per day to 400 IU per day for the prevention of rickets (Wagner & Greer, 2008). The AAP also recommends the use of iron supplements for breastfed infants beginning at the age of four months. Full term infants are able to store enough iron from their mothers during the last trimester, but those stores will be exhausted by four months of age (Johnson, 2010). Due to the lack of iron in sufficient quantities in the breast milk for the baby, the current supplemental recommendation for breastfed infants is one milligram per day per kilogram of body weight. "Iron deficiency is the most common nutritional deficiency and has negative effects on children's motor and mental development that may not be reversible with iron treatment" (Dee, Sharma, Cogswell, Grummer-Strawn, Fein & Scanlon, 2008, p. S98). Not only are supplements for the infant important, but for the breastfeeding mother as well. The current WHO recommendation for iodine supplements for mothers is 250 micrograms (Azizi & Smyth, 2009). This recommendation supports iodine sufficiency for the mother as well as the amount in her milk for the infant. Together, breastfeeding and the recommended nutrient supplements can provide the best outcome for the baby.

Benefits of Breastfeeding.

The major benefit of breastfeeding is the protective health benefits. Breastfeeding can provide benefits that range from a decreased percent of infants hospitalized for lower respiratory tract infections to a reduced risk of sudden infant death syndrome as well as decreased infant death (Johnston, Landers, Noble, Szucs & Viehmann, 2012). Breastfeeding also has a protective effect in relation to decreasing the incidence of allergies as well as asthma, atopic dermatitis and eczema. Not only does exclusive breastfeeding protect from these major medical problems, there is also a decreased risk for developing chronic diseases such as type I diabetes mellitus as well as decreasing the risk of obesity (U.S. Department of Health and Human Services, 2010).

The multiple health benefits of breastfeeding may not be the only reason that breastfeeding is recommended instead of formula feeding. There may also be cognitive benefits to the infant as well. A recent study compared exclusively breastfed infants to never breast fed infants and looked at different cognitive elements (Belfort, et al. 2013). After adjusting for factors such as socioeconomic status, mother's IQ, race, and ethnicity, the researchers found that at ages three and seven, the children who had any breastfeeding to the age of 12 months had significantly higher total scores for fine motor, visual spatial, and visual motor skills. These children also had significantly higher visual memory at age seven.

Complementary Food Recommendations.

WHO defines complementary feedings as foods added to the infants' diet, when breast milk is no longer enough to support the nutritional needs of the infant (WHO, 2013). According to AND, at the age of four to six months the infant is ready to be introduced to solid foods (AND, 2012B). Many moms introduce single grain cereals first because they can be diluted and made easier to eat for infants during their first experience eating solid foods. After the introduction of iron-fortified cereal, consuming the cereal on a daily basis will then allow the infant to meet the iron recommendation of one milligram per kilogram of bodyweight per day (Johnson, 2010). Following the introduction of single grain cereals it is common for vegetables, then fruits and finally meats to be introduced to the infant (AND, 2012B). AND does not oppose this progression of introducing foods, but does say that pureed meats and poultry may be beneficial to introduce first in order to help replenish the infant's iron stores, as these stores will be decreasing. Whichever process a parent decides to use to introduce solid foods to their infant, the most important thing to remember is to introduce food items one at a time and then wait a few days before introducing another single food item in case the baby has an allergic reaction. This process will make it easier for the parents and doctors to determine what foods the baby is allergic to (AND, 2012B). Between the ages of seven and ten months the infants are ready to begin finger foods and learning the process of feeding themselves. Foods that work best include dry cereal and teething biscuits, and infants can also start practicing with a cup with water. Regardless of the method a parent chooses to introduce solid foods to their infant, it is important to introduce a variety of fruits, vegetables, meats, and grains to reach adequate nutrient levels. The earliest experiences a child has with food can determine their food choices and food patterns for the future (Caton, Ahern, & Hetherington, 2011).

Adequacy of Complementary Feeding.

Many factors contribute to the success of complementary feeding. The timing of the introduction of solid foods is an important factor and which foods are introduced first can play a major role in nutrition adequacy. A study in 2011 found that infants were introduced to solid foods around 20 weeks of age, earlier than recommendations, but breastfed babies were generally introduced to solid foods later than formula fed babies around 21 to 22 weeks of age (Caton, Ahern, & Hetherington, 2011). Most mothers (88%) introduced cereal within the first two weeks of introducing solids, whereas only 11% offered fruits and vegetables. However, mothers thought vegetables were an important part of their own and their infant's diet and generally introduced three different vegetables in the first month of solid food introduction. The study also looked at how mothers dealt with their infants' rejection of vegetables. Many of the mothers used the repeated exposure technique as well as a modeling technique. They would show how much they enjoyed the foods to their child as they were eating together, influencing their infant to try the vegetable.

Introducing solids at six months is meant to be complementary to breast or formula feeding and to assist the baby in maintaining good nutritional status, but needs to be done by introducing a wide range of foods. In 2008, researchers looked at diet diversity and the micronutrient levels of breastfed infants and infants who were not breastfed in Madagascar (Moursi, Arimond, Dewey, Treche, Ruel, & Delpeuch, 2008). They found that the breastfed babies had lower diet diversity scores than non-breastfed babies. After categorizing foods into nine groups (grains, roots and tubers; legumes and nuts; dairy products; eggs; flesh foods; vitamin A rich fruits and vegetables; other fruits and vegetables; and fats and oils), grains, roots and tubers were the most frequently consumed food group and the main source of energy (Moursi et al., 2008). To look at the micronutrient levels, the researchers determined a score of micronutrient density adequacy (MMDA). Breastfed infants six to 11 months of age were generally consuming lower amounts of micronutrients than recommended with the exception of vitamin C and folate. Also, 22 percent of breastfed infants had a MMDA level below the 50th percentile compared to eight percent of non-breastfed infants. This number decreased as the infants increased in age (Moursi et al., 2008). These findings matched a study done in Bangladesh, which also looked at the infants' height for age. Infants who had a minimum diet diversity score of four of the six food groups had a significantly higher age z-score. (Zongrone, Winskell & Menon, 2012 p. 1699).

Parenting Stress.

A mother's interpersonal stress along with depression and other contextual factors such as poverty can together have an effect on cognitive and social cognitive skills of the children (Jensen, Dumontheil & Barker, 2013) as well as an effect on the general wellbeing of the child (Barker, 2013). Jensen et al. (2013) found that initial maternal depression led to an increase in interpersonal stress, which then led to another increase in maternal depression. This pathway was significantly associated with the infant's decreased performance IQ and social cognitive skills. The researchers also found that the infant verbal IQ was correlated with the mothers' interpersonal stress. Barker (2013) found that the dependent interpersonal stress of chronically depressed mothers compared to non-depressed mothers had a significantly higher impact on the dysregulation of their children both during pregnancy and at the age of two years. In clinical rotations for the dietetic internship, dietitians often talk about how parenting stress leads to the infant's overeating or the lack of a diverse diet, especially when food is used to comfort the infant. This commonly noted trend in the clinical setting currently has no literature to support this theory. An extensive literature review found no studies specifically related to complementary feeding of infants and parenting stress. This research will be novel in looking at diet diversity in relation to parenting stress.

Summary.

Health recommendations stress the importance of introducing complementary foods in a timely manner to provide infants with adequate nutrition to support their growth and development. Breastfed infants may be introduced to complementary foods, on average, later than formula fed infants, which could cause nutrition inadequacy. It is important to make sure they are receiving the recommended amounts of vitamins and minerals, if not from breast milk and complementary foods then from a supplement. Complementary foods may be categorized into different food groups and provide an optimal outcome when a variety of these foods are offered to the infant.

Research Problem and Hypothesis

The purpose of this study was to evaluate the growth and development of predominantly breastfed babies at six and nine months of age. The diet diversity of infants at six and nine months was described using a food group approach. Three specific hypotheses were tested. Diet diversity and infant growth as measured by the length-for-age z-scores, BMI-for-age z-scores, and head circumference-for-age z-scores will be positively correlated at both six and nine months. Parenting stress and diet diversity will be correlated at both six and nine months.

Research Population

The study includes 132 pairs of three-month-old infants (predominantly breastfed) and their mothers. The inclusion criteria for recruiting included full term single birth infants, and exclusion criteria involved infants who take more than 28 ounces of formula per week, maternal blood transfusion or illness, and current infant illness. The mother brought in the infant at three, six, and nine months of age for examination and testing.

Methods

The participants filled out a dietary intake record for the infant that required the mothers to weigh their infant before and after each feeding for a twenty-four hour period. Along with the dietary intake record they filled out the Parenting Stress Index- Short Form (Abidin, 1990). At the six and nine month visit the mother filled out the "Infant Dietary Questions" survey. This survey asked if they are exclusively breastfeeding, if they supplement with some formula, how often they give formula, the name of the formula, and how much is generally eaten at a feeding. The survey also asked about what types of solid foods the baby will eat. Foods were broken down into different categories. From this questionnaire the diet diversity score was calculated by adding together the amount of food groups the infant was exposed to at the age of six and nine months.

Statistical Analysis

The sum diet diversity was calculated by averaging the reported food groups that have been consumed. Descriptive statistics of frequency of food group consumption and population characteristics were computed. Correlations were done between length, BMI, and head circumference z scores as well as diet diversity and parenting stress.

CHAPTER II

Review of Literature

Recommendations

The current recommendation for breastfeeding is to exclusively breastfeed the infant for six months (AAP 2012; AND, 2012A; WHO, 2013). The AAP recommends Vitamin D supplementation of 400 IU beginning in the first few days of life, to all breastfed infants for the prevention of rickets (Wagner & Greer, 2008). This recommendation recently increased from 200 IU due to American infants' lack of exposure to sunlight from various factors including use of sunscreen and layering of clothes (Centers for Disease Control and Prevention [CDC], 2009). Iron is another recommended nutrient to supplement in breastfed infants. Iron supplementation after six months of age, whether it comes from an oral supplementation or iron-fortified cereals is important due to the depleting iron stores from birth (Johnson, 2010). "Iron deficiency is the most common nutritional deficiency and has negative effects on children's motor and mental development that may not be reversible with iron treatment" (Dee, Sharma, Cogswell, Grummer-Strawn, Fein & Scanlon, 2008, p. S98). Lastly, an iodine supplement of 250 micrograms for the breastfeeding mother is recommended to support the mother as well as her breastfeeding infant (Azizi& Smyth, 2009). Iodine is especially important for the infant for normal brain and nervous system development (National Health and Medical Research Council, 2010). The supplementation of these vitamins and minerals can aid the breastfeeding infant in receiving adequate nutrition during the first few months of life.

Timing of supplements to breast milk is important to provide the infant with maximum nutritional benefit. Mothers in a study that took place in the United States, who breastfed or fed their infants breast milk as well as formula (about one third of the infants) did not report giving their infants any oral iron supplements during the first two months of the infants' life, but the number of these infants receiving iron supplement increased as the infants got older (Dee, Sharma, Cogswell, Grummer-Strawn, Fein & Scanlon, 2008). Of the infants who were exclusively breastfed, 77 percent were receiving an oral iron supplementation at six months of age, 30 percent were receiving iron fortified cereal, and 14 percent were introduced to meats or meat substitutes, thus the infants were not receiving 11 milligrams of iron per day as the AAP recommends (Johnson, 2010).

Around the age of four to six months infants are ready to be introduced to iron-fortified infant cereals, and around the age of six months they can begin to try pureed fruits, vegetables, and meats (AND, 2012B). These recommendations are set forth in an effort to provide complete and adequate nutrition to the infant. Assessing infant feeding practices is not always easy because practices change rapidly with the introduction of solid foods. WHO (2010) defines eight-core infant feeding practices to track nutrition for infants aged 6-23 months of age. The eight core practices include early initiation of breastfeeding, exclusive breastfeeding under 6 months, continued breastfeeding at 1 year, introduction of solid, semi-solid or soft foods, minimum dietary diversity, minimum meal frequency, minimum acceptable diet, and consumption of iron-rich or iron-fortified food. WHO (2010) uses minimum diet diversity, defined as the proportion of children between the ages of six and 23 months who receive foods from four or more food groups as an indicator of the micronutrient intakes of infants. Minimum meal frequency is important to determine if the infants are receiving adequate amount of calories. WHO recommends that breastfed infants six to eight months of age should receive two to three meals per day, while infants nine to 23 months of age need three to four meals per day and an additional one to two snacks per day as desired.

Many infants are not exclusively breastfed. In 2013, only 76.5 percent of infants had ever been breastfed in the United States (CDC, 2013). In order to increase this number, The U.S. Department of Health and Human Services has set goals to increase the amount of infants that are ever breastfed and exclusively breastfed (U.S. Department of Health and Human Services, 2013). The goals are assessed every ten years in order to make necessary changes. These current goals are specifically laid out in the Healthy People 2020 document, which focuses on increasing different aspects of health in America. In regards to infant health, the infant care goal, MICH-21 is to increase the number of infants who are breastfed (U.S. Department of Health and Human Services, 2013). Within this goal there are more specific target goals that need to be reached. More specific goals include: to increase the number of infants who are ever breastfed to 81.9 percent (MICH-21.1), increase the proportion of infants who are breastfed at six months to 60.6 percent (MICH 21.2), and increase the proportion of infants who are breastfed exclusively through six months to 25.5 percent (MICH-21.5). In order to monitor the national breastfeeding rates and individual state rates, the CDC releases a breastfeeding report card each year. As a nation, the rates of breastfeeding at three months, six months, and exclusive breastfeeding at three months all increased from 2012 to 2013 (CDC, 2013). However, there was a slight decrease in the amount of infants ever breastfed and those who were exclusively breastfed at six months. Although, breastfeeding rates are on the rise they have not hit the target goals of Healthy People 2020. For example, the target goal to increase the proportion of infants who have ever breastfed is 81.9 percent, but in 2013 only 76.5 percent had ever breastfed (CDC, 2013 & U.S. Department of Health and Human Services, 2013). Not only is the nation a long way from reaching these targets, but Oklahoma is even further from reaching them. In Oklahoma in 2013, only 74.2 infants were ever breastfed, only 39.6 were being breastfed at six months, and only 16.6 of infants were being exclusively breastfed at six months (CDC, 2013).

Not only is it important to assess the number of infants that are breastfed, but also it is important to assess the complementary feeding of infants and toddlers. In 2002, the Feeding Infants and Toddlers Study (FITS) was conducted in the United States. This major study included over 3,000 infants between the ages of four and 24 months to determine the food patterns and intake of American children (Fox, Pac, Devaney, & Jankowski, 2004). The researchers collected two 24-hour recalls in order to estimate the usual nutrient intake of the infants and toddlers. The results were then categorized into food groups: breast milk, formula and cow's milk; grains and grain products; vegetables; fruits; meats and other protein sources; desserts, sweets, sweetened beverages, and salty snacks.

In the study, it was determined that only 40 percent of infants were consuming at least some breast milk at four to six months of age. Not only were infants not being breastfed for the recommended amount of time, researchers found 20 percent of infants were consuming cow's milk before the age of one year, and 20 percent of infants received reduced or nonfat milk before the age of two years. By four to six months of age, 66 percent of infants were receiving infant cereals and other infant grain products. As the researchers moved on to the results of the other food groups they found the results in the vegetable category were also alarming. The researchers found that at nine to eleven months of age 23 percent did not consume any vegetables that were not part of a mixed dish. Although there was a slight improvement in this number as infants reached one year of age or older, it was small. More than 77 percent of infants were consuming vegetables as a single item. Deep yellow vegetables were consumed more frequently than dark green, leafy vegetables. In all age categories, less than 11 percent of infants consumed a dark green, leafy vegetable in a day. Potatoes and other starchy vegetables were more commonly consumed and unfortunately by 15 months of age french fries and other fried potatoes were the top consumed vegetables. In the fruit category, 75 percent of infants ages seven to 18 months were eating fruit and only 67 percent of infants ages 19 to 24 months were eating fruit in a day. Of the infants that were receiving fruit, twice as many infants consumed fresh fruit than canned fruits. Meat and other protein sources became more commonly consumed after seven months when the infants began eating baby food dinner mixed dishes. By six months of age, 46 percent of infants were receiving at least one food from the desserts, sweets, sweetened beverages, and salty snacks category. This number rose for each age group category and by 19 to 24 months of age 60 percent of infant were consuming some type of cake, cookie, pie or pastry in a day.

In 2008, the FITS study was conducted once more to include a sample more representative of the United States population as well to assess any changes in children's diets since 2002 (Butte, Fox, Briefe, Siega-Riz, Dwyer, Deming, & Reidy, 2010). The 2008 study included, 3,273 infants, toddlers and pre-school aged children. In contrast to the 2002 study which examined food group intakes, the study used dietary reference intakes (DRIs) to assess infant intakes, acceptable macronutrient distribution ranges (AMDR) to assess carbohydrate, fat, and protein ranges, and the estimated average requirement (EAR) to assess micronutrient needs. Infants who were ever breastfed rose from 40 percent in 2002 to 80 percent in 2008. The diet consumed by infants that were transitioning to solid foods was comprised of high protein and low fat. Infants protein intake fell within the AMDR, while 23 percent did not get enough fat, and 5 percent did not consume enough carbohydrates. The researchers found that 12 percent of infants six to 11 months were not receiving adequate amounts of iron, and 6 percent were not receiving adequate zinc. The researchers found that carbohydrate, vitamin A, vitamin E, and vitamin C, calcium, phosphorus, magnesium, sodium and potassium intake were significantly lower in infants six to 11 months as well as infants 12 to 23 months in 2008 compared to the 2002 study. On the other hand, infants were consuming more folate, vitamin B12, and zinc in 2008 than 2002. Excessive sodium was more prevalent in 2002, while excessive zinc was more prevalent in 2008.

Although some vitamin and mineral intake increased in 2008, some major vitamin intake decreased such as vitamin A, E, and C.

A recent study examined the results of the FITS studies and how these results have implications for the future related to obesity. The researchers found that compared to the estimated energy requirement put out by the CDC that is based on the average height and weight for U.S. children that the infants and children in the FITS studies were consuming energy in excess of their needs (Saavedra, Deming, Datillo, Reidy, 2013). The study also explains that although 80 percent of infants in the 2008 FITS study were initially breastfed, only 49.4 of infants were still breastfeeding at six months. The article goes on to examine the relationship between breastfeeding and the decreased risk of overweight and obesity, which may be related to infant self-regulation of intake compared to when the infant is bottle-fed. Another area of improvement from 2002 to 2008 was the decline of early introduction to infant cereals. In 2002, 26 percent of infants were introduced to cereal before four months of age and in 2008 only ten percent of infants were introduced to cereal before four months of age. In 2008, there was also an increase in the amount of infants that were consuming fruits in a day. For infants ages nine to 23 months, 73 to 84 percent of infants consumed fruits in a day. Vegetable intake was similar in 2002. The lack of fruit and vegetable consumption in infancy is important because fruit and vegetable intake at 18 months of age mirrors the intake of an American adult, where only ten percent of energy comes from fruit and vegetables therefore contributing to obesity later in life.

Duration of Breastfeeding and Diet Diversity

The importance of breastfeeding and the introduction of complementary feeding does not only involve when to start solids, but also how long to continue breastfeeding. WHO and AND put an emphasis on the introduction of complementary foods, but do not define an exact time to completely wean from breastfeeding. WHO (2013) states that breastfeeding is an important source of energy for infants up to 23 months, while AND (2012A) focuses on exclusive breastfeeding but does not define an endpoint for breastfeeding. While research on the diet diversity of infants is growing, most of it has been conducted internationally. A research study done in 1998 attempted to determine the effects of prolonged breastfeeding and the timing of complementary foods on nutritional status (Onyango, Koski, & Tucker, 1998). The researchers on this Kenyan study evaluated 154 children ages 12 to 36 months that were either partially or fully weaned from breast milk. The food intake of the children was evaluated by three 24-hour recalls in non-consecutive days as well as recipes for the meals they consumed. Older siblings were also asked for the child's food intake in case the mother was unaware of some snack intake. From these records, researchers calculated a diet diversity score for each infant. Mothers also provided information on when infants were first introduced to complementary foods such as porridge and fruits and vegetables and were asked to rank the infants' appetite. The frequency and quantity of breast milk consumption was not recorded, only whether or not they were still consuming breast milk. After information was recorded from the mothers the researchers collected anthropometric data according to the United Nations procedures. From this data the height-for-age, weight-for-age, and weight-for-height were interpreted.

The researchers examined food intake characteristics and determined that exclusive breastfeeding after three months of age was rare. They found that 23 percent of infants received porridge the first month of life, while at four months of life 86 percent of the infants had received porridge. The researchers found that infants who were fully weaned had significantly greater diet diversity than partially weaned infants, and overall mothers of fully weaned infants tended to give their infants a higher appetite ranking. There were no significant differences in relation to the anthropometric measurements, but diet diversity was consistently and positively associated with each anthropometric measurement. Partially breastfed infants also had significantly lower intake of riboflavin and niacin. While breastfeeding is an important part of infancy, the results of this study show how an extended duration of breastfeeding, lasting up to 36 months can negatively affect the diet diversity of infants.

A similar study done in Ghana aimed to eliminate mothers' misconceptions that a longer duration of exclusive breastfeeding could reduce adequate feeding when infants are introduced to complementary foods because infants become less accepting of new foods (Aryeetey & Goh, 2013). This study looked at 294 infants in Ghana ages 9-23 months. A 24 hour recall was taken about the day preceding the interview and questions were asked regarding child feeding practices such as if the child ate from three or more food groups, when the child was introduced to complementary foods and if the child was eating less than usual in the last week. The researchers defined infants as adequately fed if they were fed complementary foods three times in the past 24 hours, were fed complementary foods from at least three food groups, and received breast milk in the last 24 hours. The researchers found that there were no significant differences in the adequacy of the diet in infants who were exclusively breastfed for at least five months compared to infants who were breastfed for a shorter amount of time. Significant factors in the adequacy of the infants' diet included the number of people involved in the infants' feeding as well as the mothers' report of not liking food. The number of people involved in feeding showed a significant positive association with the adequacy of the infants' diets. There was also a significant association between mothers with a secondary education and mothers with a higher income having infants who were adequately fed.

Recent research suggests that the duration of breastfeeding for an infant may be correlated with larger diet diversity when the child becomes a toddler (Scott, Chih, & Oddy, 2012). Researchers looked at two separate food categories, core food variety scores (CFVS) and fruit and vegetable variety scores (FVVS) in Australian two year olds who ranged from never being breastfed to being breastfed for more than nine months. Duration of breastfeeding was significantly and directly positively associated with both the CFVS and FVVS. One factor that may lead to this correlation is that infants who are breastfed are exposed to more flavors in breast milk compared to infants who only receive formula. “Variations in flavor from mother to mother and from feeding to feeding suggest that breastfeeding, unlike formula feeding, provides the infant with the potential for a rich source of sensory variety” (Mennella & Trabulsi, 2012, p. 44). The researchers put mothers who planned to breastfeed after giving birth into three different research groups. The first group drank carrot juice a few times a week, each week, during the last trimester of their pregnancy; the second drank carrot juice a few times a week, each week, during the first three months of lactation; and the third group was a control group and avoided carrots and carrot juice by drinking mainly water during pregnancy and breastfeeding The results of this study showed that the mothers who had been drinking carrot juice and eating carrots had infants with a higher acceptance of carrot infant cereal when they were being introduced to solid foods and being weaned from breast milk. Therefore, the diet diversity of the breastfeeding mother has potential to increase the diversity of their breastfed infant’s diet.

Diet Diversity

As infants transition to solid foods and complementary feedings, the mother still plays an important role in their diet and the importance of the mother’s diet may still be as beneficial in complementary feedings as it was during breastfeeding. One study looked at the relationship between the mother’s diet diversity compared to their child’s diet diversity in Bangladesh, Vietnam, and Ethiopia (Nguyen et al., 2013). The study used a questionnaire developed by WHO that recalled the infant and the mother’s past 24-hour consumption of food based on the mother’s recollection. The survey grouped foods into seven food groups and of those food groups the participant was to state whether or not a food from that food group had been consumed in the past 24 hours. The researchers concluded that all three countries had a similar diet with a starch as their staple and less consumption of flesh foods, dairy and eggs. The researchers also found that in all three countries, the mothers who consumed at least four food groups had infants that were reaching minimum diet diversity as defined by consuming four different food groups. It was concluded that the maternal diet diversity was significantly associated with the infant's diet diversity scores. In Bangladesh and Vietnam infants were twice as likely to achieve minimum diet diversity if their mothers were consuming at least four groups and in Ethiopia the infants were five times as likely to achieve the minimum diet diversity if their mothers were consuming four or more food groups after adjusting for child, maternal and household covariates.

Repeated Exposure

Repeated exposure, as mentioned by Caton et al. (2011), can be an important experience for infants. If an infant does not like one type of food the first or second time, research suggests it would be important to offer the food a few more times instead of offering something else in its place. Once a parent has begun introducing solid foods to her infant, repeated exposure to a specific food could increase the acceptance of the food thus increasing the diet diversity of the diet. In a 2007 study, researchers found that repeated exposure to a target fruit (pears) and a target vegetable (green beans) led to an increase in consumption for the pears and green beans (Mennella, Nicklaus, Jagolino & Yourshaw, 2007). This method of food introduction could be beneficial especially for certain fruits and vegetables such as cruciferous vegetables and citrus fruits, that are important to overall health, but tend to have a bitter taste (Stein, Nagai, Nakagwa, & Beauchamp, 2003).

Lastly, variety of new foods to the infants may lead to higher acceptance of foods. A study done in Philadelphia, showed that formula fed infants had a higher acceptance to pureed carrots and pureed chicken if they were introduced to solid foods with a variety of vegetables rather than just one vegetable (Gerrish & Mennella, 2001). In this particular study, there were three groups: a carrot group, a potato group, and a variety of vegetable group. The experiment was 12 days long and was performed on infants who had only been formula fed and had begun to eat infant cereal. On the first day, each infant was introduced to carrots in the clinic. At home for the next nine days, the infants received carrots if they were in the carrot group, potatoes if they were in the potato group, or rotated each day between peas, squash and potatoes if they were in the variety of vegetable group. On the 11^{th} day the infants were brought back in to receive the target food of the carrot again and the 12^{th} day, they came back one more time to receive pureed chicken. After the exposure to carrots or variety of vegetables, the infants ate significantly more carrots after the exposure period in comparison to the first day they received the carrots. There were no significant differences in the amount of carrots eaten in the potato group after the exposure period. There were also significant differences in the groups when they were introduced to pureed chicken after the exposure period. The variety of vegetable group ate significantly more pureed chicken than the carrot group. Although this study examined formula fed infants, it is applicable to breastfed infants and important to practice as a parent begins introducing solids, especially if the mother had limited variety in her diet as she was breastfeeding.

Parenting Stress and Adequate Nutrition

Stress is common among new parents, especially first time parents. Stress has the ability to change people's attitudes and even their original plans (O'Brien, Buikstra, Fallon, Hegney, 2009). For example, in a breastfeeding situation, if the mother becomes too stressed, it may be easier to feed formula even though breastfeeding for six months was the mother's previous goal. Parenting stress is a specific kind of stress that is perceived by the parents and comes from the day-to-day struggles of being a parent (Ostberg & Hagekull, 2000). Australian researchers looked at the psychological factors that were related to the duration of breastfeeding in new mothers (O'Brien et al., 2009). Stress was among one of the top five indicators for how long mothers exclusively breastfed their infants. Other indicators for breastfeeding duration included mother's priorities and self-efficacy, faith in the natural superiority of breastfeeding, adaptability and flexibility, and breastfeeding self-efficacy. Not only does the common stress from being a new parent affect the duration of breastfeeding, but also distress about breastfeeding itself may affect the duration. For example, being worried about breastfeeding and the physical change of the body after breastfeeding affects the duration (Rondo & Souza, 2007). Although the link between maternal stress and the duration of breastfeeding has been explored there is currently no research to support that this stress may also affect how a mother feeds her infant when it is time to introduce complementary foods.

In 2011, researchers examined the relationship between how mothers perceived their infants (such as fussy or happy) and the timing of the mother introducing solid foods to the infant (Wasser, Bentley, Borja, Goldman, Thompson, Slining & Adair, 2011). It was determined that infants with higher scores on *activity levels* and *distress to limitations* were twice as likely to be introduced to solid foods before the age of four months compared to infants with lower scores. The researchers did not see the same trend in the category of *low intensity pleasure*. These infants may perceived as happier to their mothers and show pleasure even when just sitting on the floor quietly playing with a toy or being rocked by their mothers. This indicates that more active and fussy infants were fed solid foods around the age of four to six months, before the recommended time of introduction of solid foods around the age of four to six months.

Parenting stress has been linked to many aspects of parenting including general behavior of young children and behavior problems in children with chronic illness (Park & Walton-Moss, 2012). An Icelandic study aimed to determine the relationship between depressive symptoms and parenting stress to exclusive breastfeeding at two to three months postpartum (Thome, Alder, & Ramel, 2006). The researchers used the Parenting Stress Index, Short-form to measure parenting stress. The researchers also collected feeding method questionnaires that were self-reported by the participants. These questionnaires categorized the feeding into exclusively breastfeeding, supplemented breastfeeding, bottle-feeding, and semi-solid feeding. Exclusive breastfeeding for the study included supplements of Vitamin A and D drops or cod liver oil and supplemented breastfeeding included the use of liquids such as baby formula, juices, water, and cow's milk. The researchers determined that all three of the parenting stress index subscales were significantly correlated with maternal education. Mothers who were in the exclusively breastfeeding category had significantly lower scores on the impaired interaction with child subscale as well as the difficulty of the child's behavior subscale. Parent distress scores of exclusively breastfeeding mothers were lower as well, but not in significant amounts. Lastly, all three subscales were significantly correlated to the depression scores that were calculated from the Edinburgh Postnatal Depression Scale (EPDS). Although the three subscales may be associated with difficulties and sometimes cessation of breastfeeding, maternal education was the strongest predictor of exclusive breastfeeding. Therefore, mothers with higher education are more likely to continue exclusive breastfeeding, despite the stress that may come with parenthood.

Summary

Breastfeeding is an important part of infants' diets, but the duration of breastfeeding can have an effect on the diet diversity of the infants as complementary feeding is begun. Breastfeeding of the infant for 36 months or more was shown to decrease the diet diversity compared to infants who were fully weaned at this age (Onyango, Koski, & Tucker, 1998). On the other hand, breast milk contains flavor variations of the mother's diet so the longer an infant is breastfed, the more flavors he or she may be exposed to. Therefore, the infants may accept a wider range of foods during complementary feeding. Repeated exposure and a variety of food offerings can lead to larger diet diversity in infants. Lastly, parent stress may be an important factor in the duration of breastfeeding and the timing of complementary feeding. Parents with higher perceived stress may end exclusive breastfeeding sooner or introduce complementary foods earlier in order to relieve some of their perceived stress. This may in turn affect the infants' diet diversity.

CHAPTER III

Methodology

Background and Design

This study examined the relationship between diet diversity and the BMI as well as the length of the infant. The study also examined the relationship between parenting stress and diet diversity. This study was part of a larger study approved and funded by the United States Department of Agriculture examining the relationship between maternal levels of micronutrients and infant cognitive development that was conducted between 2008 and 2010. The Oklahoma State University Review Board approved the study.

Sample

The larger study included 132 three-month-old infants (predominantly breastfed) and their mothers, but only 120 completed all of the information at the three-month visit to be included in the current study. The inclusion criteria for recruiting included full term single birth infants, and exclusion criteria involved infants who took more than 28 ounces of formula per week, maternal blood transfusion or illness, and current infant illness. The mother brought in the infant at three, six, and nine months of age for assessment. The average age of the 120 infants that participated at the three-month visit was 91 days old; the average age of the 118 infants that participated in the six-month visit was 182 days old, and the average age of the 113 infants that participated in the nine-month visit was 272 days old.

Procedures

Before initial testing of the infants at three months of age, the mothers filled out a demographic questionnaire and Parenting Stress Index in addition to other assessments not analyzed in the current study. The infants then participated in three visits at three, six, and nine months of age during which anthropometric measurements were assessed as well as participating in other procedures not analyzed in the current study. At three months of age, the mothers completed a 24-hour feeding protocol for the infant by weighing the infant before and after he or she was breastfed each time for a twenty-four hour period. At the six and nine month visit the mothers filled out the infant dietary questions form; the same form was used at six and nine months.

Assessments/Questionnaires

Demographics.

The mother filled out the demographic information questionnaire (see appendix) at the initial visit. This questionnaire provided general characteristics about the infant and their families for the sample population; for example, ethnicity, household income, mother's education level, gender of the infant, and whether or not the family received state or federal financial assistance were questioned.

Anthropometry.

The anthropometric measurements were assessed at each visit. The measurements included the infants' length and weight, which were measured with the baby wearing only a t-shirt and a dry diaper. The lengths were measured on an infant length board (Shorr Production, Olney MD, accuracy to 0.1 cm). Each infant's length was measured twice for accuracy, and if the two measurements differed by more than one centimeter, a third measurement was taken. The outlier was then discarded before averaging the two measurements. During the length measurements two research assistants were used to provide accuracy. The measurer assured the infant was flat on the board with his or her head against the base, then firmly pressed the infant's knees to extend his or her legs, while the second assistant held the infant's head against the top of the board for stabilization in order to provide accurate length measurement. Infants were weighed using a digital infant scale. The digital infant scale was designed to produce an automatic average of multiple measurements (Seca, Columbia, MD, accuracy to 0.002). The head circumference was also taken with a non-stretchable, feed-through plastic measuring tape. The tape was placed above the eyebrows and ears to measure around the largest part of the head. Each head circumference measurement was taken three times and the average was used to calculate the z scores. WHO Anthro software was used to calculate BMI and the z-scores, using the infants' anthropometric measurements.

Dietary Assessment.

The infants were screened for predominant breastfeeding before the initial visit. The study utilized two methods of dietary assessment, the weights of the infant before and after breastfeeding at three months of age as well as a dietary questionnaire at the six and nine month visit. The Pregnancy Risk Assessment Monitoring System (PRAMS) questionnaire was also utilized to determine the mothers' health before and during pregnancy and asked additional questions about items consumed other than breast milk at the three-month visit (CDC, 2004). PRAMS also had questions on smoking.

At the initial visit at three months, parents were provided with a digital scale (Seca, Columbia, MD, accuracy to 0.002 kg) to take home and were asked to record the weight of the infant before and after each feeding for a 24-hour period; the time of the feeding; the food the infant ate at that time; as well as a description of the food. Breast milk and formula, as well as any other liquid given in a bottle during this twenty-four hour span were to be recorded as well. For the solid foods consumed during this period, parents were asked to write details such as the brand name of the food, and save the labels for the next visit if it was possible. Instructions were included on the data collection form (see appendix, one and two) for the parents on how to weigh their babies such as making sure the scale was zeroed out before weighing, what decimal place to use when recording the weight, how to record the time the feeding began and ended, not to change the diaper during this period of time, and weigh the baby in the same clothes or blanket at the beginning and the end. Of the 132 mother-infant pairs, eight did not complete the 24-hour recall. Discarding these eight pairs left a data set of 124 mother-infant pairs. In addition, four recalls were discarded due to being incomplete, as determined by having only four or fewer feedings in a 24 hour period. Of the remaining 120 pairs, 23 of the 24-hour recalls were missing one or two weights, usually with notes about feeding in the middle of the night or "messiness requiring cleaning". To replace the missing weight data, the other weight changes were averaged to the nearest hundredth and this average weight was used for the missing data. The weights were recorded in grams and the weight change was converted to fluid ounces by dividing grams by 30.8. This number comes from The Food Processor, Version 10.11.0, Salem Oregon. Total feeding volume was then determined by adding the derived volume of breast milk in fluid ounces to the fluid ounces consumed by bottle (breast milk and/or formula).

Infant Dietary Questions.

At the six and nine month visit the mother filled out the "Infant Dietary Questions" survey, the specific questions and the results at both time points are located in appendix three. The survey asked general breastfeeding questions such as duration, exclusivity, and supplements and medications the infants received throughout the day. The survey also asked questions about the infants' complementary feeding habits. Foods were broken down into different categories. The categories were baby cereal, infant fruit, infant vegetables, baby meat, infant "dinners," infant juice, infant desserts, other homemade puree or ground baby food, mashed table food, cereal (not infant), regular juice, cow's milk, and other foods, a slightly more condensed list than that used in the Feeding Infants and Toddlers Study (Fox, Pak, Devaney & Jankowski, 2004). The survey also asked general complementary feeding questions such as frequency of infant meals.

From this questionnaire, the diet diversity score was calculated. There was a maximum diet diversity score of five because it was determined that every infant was receiving breast milk or formula, therefore there was no dairy group included in the score. Desserts were also excluded from the diet diversity score due to a possibly low micronutrient value. The five groups included grains, which consisted of infant cereals and regular cereals; fruits, consisting of fruits, infant juices, and regular juices; vegetables; meat consisting of meats and infant dinners; and table food. The diet diversity score was then determined by how many of the food groups each infant had been introduced to at both the six and nine month visits.

At six months, only one infant had consumed all five food groups, and because very few had been introduced to table food the infant was thought to be an outlier. When the descriptive statistics were calculated without table food as a food group it showed that two infants were introduced to table foods first, and had yet to receive any other solid foods. Therefore, table food was included in the diet diversity score at both six and nine months.

Parenting Stress Index.

The Parenting Stress Index (PSI), short form (Abidin, 1990), was a condensed version of the full length, 100 question PSI. The 36 questions on the PSI short form were identical to those used in the full-length version, and could be answered by strongly agree, agree, not sure, disagree, or strongly disagree. The PSI short form examined three factors, Parental Distress (PD), Parent-Child Dysfunctional Interaction (P-CDI), and Difficult Child (DC). There were 12 questions in each factor, which equaled the 36 questions for Total Stress. Total stress scores could then range from 112 (being highly stressed) to 39 (very low stress). Parental Distress represented the stress related to personal factors that directly related to the distress that comes from parenting. Parent-Child Dysfunctional Interaction focused on the relationship of the parent and child, for example, whether the parent felt the child met their expectations or if the parent felt alienated from the child. Lastly, Difficult Child related to the behavior of the children and how their parents perceived the behavior as easy or difficult. In a1994 study, the alpha reliabilities of the PSI-SF compared to the full-length version were .79 for PD, .8 for P-CDI, .78 for DC and.9 for total stress (Roggman, Moe, Hart, & Forthun, 1994). Data are presented using standards provided by the publisher (Abidin, 1990). The normal range for scores was between the 15^{th} and 80^{th} percentiles, while a high score was above the 85^{th} percentile. The cut points were derived from the Parenting Stress Index long-form through the examination of the long form scores (Abidin, 1990).

Statistical Analysis

The diet diversity scores were calculated for each infant at the age of six and nine months by adding up the number of food groups they were reported to had been consumed. This gave the sum diet diversity score for each infant ranging from zero to five. Descriptive statistics included frequency of food group consumption at each time point, as well as mean food group consumption scores. Descriptive statistics of sample characteristics were also computed including demographic variables and growth variables and use of supplements and medications. To test hypothesis one, correlations between length, BMI, and head circumference z-scores and diet diversity scores were done. To test hypothesis two, correlations between diet diversity and parenting stress were done. Both total and sub-scales scores were assessed. Significance was set at p <05.

CHAPTER IV

Results

This section will first discuss the descriptive data and then present information testing the two hypotheses.

Demographics

Table one summarizes the information about the mother-infant pairs as provided at the initial three-month visit. Just over half of the infants were female at 56.7 percent and the majority of the infants were white at 85.8 percent. The population sample was relatively low-risk due to the maternal education level and the average household income. A majority of the mothers had a college degree or higher as seen by 26.7 percent of the mothers having a college degree and 39.2 percent of the mothers having a post graduate degree. Also, 24.6 percent of the families had a household income of 40,001 dollars to 60,000 dollars and 26.3 percent had a household income of 60,000 dollars or more. Just over half of the mothers were unemployed at 53.8 percent. Of the 120 mother-infant pairs, 32 pairs participated The Special Supplemental Nutrition Program for Women, Infant, and Children, 9 pairs were on food stamps, and 12 were on Medicaid. Only three mothers agreed or strongly agreed that their child was less healthy than other children, and only 21 mothers stated their infants have ever been seriously ill. The majority of all mothers believed themselves to be in good health, only two considered their health to be fair. Lastly, there were 17 mothers who had smoked at least 100 cigarettes in the past two years.

Table 1. Demographic Results

Infant Gender (n=120)	
Female	68 (56.7%)
Male	52 (43.3%)
Infant Race (n=120)	
Native American	9 (7.5%)
African American	1 (0.8%)
Hispanic	4 (3.3%)
Asian	3 (2.5%)
White	103 (85.8%)
C-Section Delivery (n=119)	
No	92 (77.3%)
Yes	27 (22.7%)
Maternal Education (n=120)	
Less than high school diploma	1 (0.8%)
High school graduate	5 (4.2%)
Some college	35 (29.2%)
College graduate	32 (26.7%)
Post graduate or above	47 (39.2%)
Employment (n=119)	
Unemployed	64 (53.8%)
Employed part-time	21 (17.6%)
Employed full-time	34 (28.6%)
Income Level (n=118)	
Under $15,000	12 (10.2%)
$15,001 to 25,000	20 (16.9%)
$25,001 to 40,000	26 (22.0%)
$40,001 to 60,000	29 (24.6%)
Over $60,000	31 (26.3%)
Marital Status (n=120)	
Married	109 (90.8%)
Unmarried	11 (9.2%)
Number of Children (n=119)	
1	55 (46.2%)
2	39 (32.8%)
3	16 (13.4%)
4	6 (5.0%)
5	3 (2.5%)

Table two summarizes the anthropometric data outcomes as a z score from the three, six, and nine months visits. At the three month visit, the data set begins with 120 infants, but by six and nine months a few mother-infant pairs dropped out, resulting in fewer infants at the six and nine month visit. Also, due to fussy infants there are fewer head circumference scores. The mean

BMI-for age z score was 0.1, 0.3, and 0.66 at three, six, and nine months of age, respectively. The mean length/height-for-age z score was -0.1, -0.26, and -0.49 at three, six, and nine months of age, respectively. The mean head circumference for age z score was 0.64, 0.60, and 0.81 at three, six, and nine months of age, respectively

Table 2. Anthropometric Data

	N	Mean	Standard Deviation
Birth weight (kilograms)	120	3.47	0.42
3 Month Visit			
BMI-for-age z-score	120	.10	1.06
Weight-for-age z-score	120	.02	0.99
Length/height-for-age z-score	120	-.10	1.06
Head circumference-for-age z-score	119	.64	0.97
6 Month Visit			
BMI-for-age z-score	118	.30	1.12
Weight-for-age z-score	118	.07	1.03
Length/height-for-age z-score	118	-.26	1.07
Head circumference-for-age z-score	117	.60	1.01
9 Month Visit			
BMI-for-age z-score	112	.66	1.03
Weight-for-age z-score	113	.22	1.07
Length/height-for-age z-score	112	-.49	1.17
Head circumference-for-age z-score	112	.81	1.01

Dietary Information

Next, table three shows the age of infants when they began receiving “anything besides breast milk”. This may have included items such as water, formula, supplements or infant solid foods. These data were from the initial three-month visit; therefore 66 percent of infants still had not received anything besides breast milk.

Table 3. Age of infant when received anything besides breast milk

Age of Introduction to anything besides breast milk		
1st Month of life	24	(20.1%)
2nd Month of life	9	(7.5%)
3rd Month of life	7	(5.8%)
Nothing besides breast milk	80	(66.6%)

Table four depicts the results of the 24-hour recall of the infant weight changes after breastfeeding at three months of age. Although the subjects were predominantly breastfed, the study allowed for minimal formula feeding. Only three infants consumed formula during this 24-hour period in addition to breast milk. The total feeding includes breast milk and formula.

Table 4. Diet Recall: 3-Month Visit

	N	Mean	Standard Deviation
Total Formula Received (Ounces)	3	21.00	15.52
Total Feeding (Ounces)	120	25.27	6.58
Number of Feedings in 24 Hours	120	7.95	1.54
Average Volume Per Feeding Ounces	120	3.28	1.04

Table five summarizes the formula usage of the infants at six and nine months. At six and nine months, the majority of the infants were not given any formula. At both six and nine months there were more infants that were said to have received no formula in the formula frequency category compared to the type of formula category for the same time point. This was due to a mother answering that the infant received formula rarely (only one to two times), but continued to list the type of formula that was given that one or two times. Although only a portion of infants had been introduced to formula by six and nine months, the ones who were receiving formula were for the most part receiving formula that was not iron fortified.

Table 5. Formula Consumption at 6 and 9 Months

	N=114
Type of Formula: 6 Month Visit	
Iron Fortified	6 (5.3%)
Regular Formula	29 (25.4%)
No Formula	79 (69.2%)
Formula Frequency: 6 Month Visit	
More than twice daily	13 (11.4%)
1-2 times daily	13 (11.4%)
1-3 times per week	6 (5.3%)
None	82 (71.9%)
Type of Formula: 9 Month Visit	
Iron Fortified	9 (7.9%)
Regular Formula	32 (28.1%)
No Formula	73 (64.0%)
Formula Frequency: 9 Month Visit	
More than twice daily	28 (24.5%)
1-2 times daily	10 (8.8%)
1-3 times per week	2 (1.8%)
None	74 (64.9%)

Table six summarizes the age of introduction to solid foods and which foods the infants had been introduced to by six and nine months. The information was provided by recalls of the mothers. Therefore, there are differences in the number of infants who had been introduced to solids at four to five months and six months, possibly due to a recall error at the nine-month visit. At six months of age there were still 19 infants who had not yet been introduced to solid foods, along with five of these infants still not being introduced at nine months of age. Not only were infants being introduced to solids later than the recommend four to six months, they were also not being fed solids as frequently in a day as recommended. At six months of age only 23 of the infants were being fed solid foods two to three times per day as WHO (2010) recommends. At nine months of age, the WHO (2010) recommendation increases to three to four times per day, and at the nine-month visit only 43 infants were being fed enough to meet this recommendation. Intake of one and two percent milk was not included in the table because no infants had received any at six or nine months of age.

Table 6. Solid Food Consumption at 6 and 9 Months

	N=114
Age of Introduction to Solids: 6 Month Visit	
1-3 Months of age	3 (2.6%)
4-5 Months of age	75 (65.8%)
6 Months of age	17 (14.9%)
No introduction yet	19 (16.6%)
Age of Introduction to Solids: 9 Month Visit	
1-3 Months of age	3 (2.6%)
4-5 Months of age	47 (41.2%)
6 Months of age	47 (41.2%)
7-8 Months of age	12 (10.5%)
No introduction yet	5 (4.4%)
Has the infant been introduced to infant cereal?	
6 Month Visit: Yes	87 (76.3%)
9 Month Visit: Yes	95 (83.3%)
Has the infant been introduced to fruit?	
6 Month Visit: Yes	35 (30.7%)
9 Month Visit: Yes	94 (82.5%)
Has the infant been introduced to vegetables?	
6 Month Visit: Yes	53 (46.5%)
9 Month Visit: Yes	92 (80.7%)
Has the infant been introduced to meat?	
6 Month Visit: Yes	6 (5.3%)
9 Month Visit: Yes	58 (50.9%)
Has the infant been introduced to infant dinners?	
6 Month Visit: Yes	0 (0.0%)
9 Month Visit: Yes	19 (16.7%)
Has the infant been introduced to infant juice?	
6 Month Visit: Yes	11 (9.6%)
9 Month Visit: Yes	38 (33.3%)
Has the infant been introduced to desserts?	
6 Month Visit: Yes	0 (0.0%)
9 Month Visit: Yes	12 (10.5%)
Has the infant been introduced to homemade foods?	
6 Month Visit: Yes	17 (14.9%)
9 Month Visit: Yes	53 (46.5%)
Has the infant been introduced to table food?	
6 Month Visit: Yes	12 (10.5%)
9 Month Visit: Yes	71 (62.2%)
Has the infant been introduced to regular cereals?	
6 Month Visit: Yes	3 (2.6%)
9 Month Visit: Yes	55 (48.2%)
Has the infant been introduced to regular juice?	
6 Month Visit: Yes	1 (0.9%)
9 Month Visit: Yes	13 (11.4%)
Has the infant been introduced to whole milk?	
6 Month Visit: Yes	0 (0.0%)
9 Month Visit: Yes	1 (0.9%)

Along with the low frequency in the feeding of solid foods, there was low supplement intake at both six and nine months. Table seven summarizes the supplement intakes of the infant at both time points. Only about ten percent of infants were being given a nutrient supplement that contained vitamin D, iron or both.

Table 7. Supplement Intake at 6 and 9 Months

	N=114
Six Month Supplement Intake	
Multivitamin	3 (2.6%)
Vitamin D	6 (5.3%)
Vitamin D with Iron	1 (0.9%)
Tri-Vi-Sol (Vitamins A, D, C)	1 (0.9%)
Other*	11 (9.6%)
No supplements	92 (80.7%)
Nine Month Supplement Intake	
Multivitamin	2 (1.8%)
Vitamin D	5 (4.4%)
Vitamin D with Iron	1 (0.9%)
Tri-Vi-Sol (Vitamins A, D, C)	1 (0.9%)
Other*	12 (10.5%)
No supplements	93 (81.6%)
*Other supplements are those not containing iron or Vitamin D and may be an over the counter medicine such as Tylenol or Claritin.	

Parenting Stress

In table eight, the results from the Parenting Stress Index are summarized. A mean score for each factor was calculated from all of the mothers' scores. For parental stress, the mothers had a mean score of 25.05 and standard deviation of 7.747, the mean parent-child dysfunctional interaction score was 17.02 and the standard deviation was 4.989, the difficult child average mean score was 21.32 and the standard deviation was 6.629, and lastly the total stress mean score was 63.1 and the standard deviation was 15.744. In general, the mothers in this population were less stressed than the general population. Less than 14 percent of mothers were considered above average stress in the parental distress factor, while less than ten percent of mothers were considered above average stress in the remaining factors.

Table 8. Parenting Stress Index Results

Parental Distress: Norm Average 25 (N=120)	
At or Below Average	73 (60.8%)
Above Average	33 (27.5%)
High Stress (At or Above 33)	14 (11.7%)
Parent-Child Dysfunctional Interaction: Norm Average 19 (N=120)	
At or Below Average	88 (73.3%)
Above Average	25 (20.8%)
High Stress (At or Above 26)	7 (5.8%)
Difficult Child: Norm Average 25 (N=119)	
At or Below Average	90 (75.6%)
Above Average	22 (18.5%)
High Stress (At or Above 33)	7 (5.9%)
Total Stress: Norm Average 69 (N=119)	
At or Below Average	85 (71.4%)
Above Average	25 (21.0%)
High Stress (At or Above 86)	9 (7.6%)

Diet Diversity and Correlations

Diet diversity scores were calculated at both six and nine months, as shown in table nine. It was assumed that all infants were consuming an item from the dairy group, either from formula or breast milk. Therefore, when someone received a score of zero, they were still consuming from one food group, or if they received a one, they were consuming food from one food group in addition to the dairy group, and so on for each diet diversity score. Limited diet diversity may be expected at six months, due to the recommendation to begin introducing solids around four to six months. However, for older infants WHO (2010) determined a minimum acceptable diet; that infants should receive at least four food groups. In this sample, approximately 16 percent of infants were not meeting the minimum acceptable diet at nine months.

Table 9. Diet Diversity Scores at 6 and 9 Months

Score	N=114
Diet Diversity at 6 Months	
0	21 (18.4%)
1	33 (28.9%)
2	27 (23.7%)
3	24 (21.1%)
4	8 (7.0%)
5	1 (0.9%)
Diet Diversity at 9 Months	
0	3 (2.6%)
1	4 (3.5%)
2	12 (10.5%)
3	22 (19.3%)
4	36 (31.6%)
5	37 (32.5%)

As seen in table ten, there were no significant correlations between diet diversity, length/height-for age z-scores, BMI-for-age z-scores, and head circumference-for-age z-scores at six months. There were also no significant correlations between diet diversity and parenting stress.

Table 10. Diet Diversity Correlations at 6 Months

		Diet Diversity at 6 Months
Length/Height-for-age z-score At 6 Months	Pearson Correlation Sig. (2-tailed) N	-.05 .59 113
BMI-for-age z-score At 6 Months	Pearson Correlation Sig. (2-tailed) N	.08 .39 113
Head Circumference-for-age z-score At 6 Months	Pearson Correlation Sig. (2-tailed) N	-.05 .60 112
Parental Distress	Pearson Correlation Sig. (2-tailed) N	.01 .91 114
Parent-Child Dysfunctional Interaction	Pearson Correlation Sig. (2-tailed) N	-.02 .83 114
Difficult Child	Pearson Correlation Sig. (2-tailed) N	-.083 .383 113
Total Stress	Pearson Correlation Sig. (2-tailed) N	-.03 .79 113

At nine months of age, although diet diversity scores had somewhat increased for the infants, there were still no significant correlations between diet diversity, length/height-for age z-scores, BMI-for-age z-scores, and head circumference-for-age z-scores. Similar to six months of age, there were also no significant correlations between diet diversity and parenting stress.

Table 11. Diet Diversity Correlations at 9 Months

		Diet Diversity at 9 Months
Length/Height-for-age z-score At 9 Months	Pearson Correlation Sig. (2-tailed) N	.09 .36 111
BMI-for-age z-score At 9 Months	Pearson Correlation Sig. (2-tailed) N	.07 .50 111
Head Circumference-for-age z-score At 9 Months	Pearson Correlation Sig. (2-tailed) N	.06 .52 111
Parental Distress	Pearson Correlation Sig. (2-tailed) N	-.004 .97 114
Parent-Child Dysfunctional Interaction	Pearson Correlation Sig. (2-tailed) N	-.09 .34 114
Difficult Child	Pearson Correlation Sig. (2-tailed) N	-.042 .657 113
Total Stress	Pearson Correlation Sig. (2-tailed) N	-.05 .58 113

CHAPTER V

Discussion

Summary

Current health recommendations promote exclusive breastfeeding for the first few months of life as well as a timely introduction of solid foods around the age of four to six months to support infants' growth and development. Many American infants are not being fed to meet the recommendations that are supported by AAP (2012), WHO (2013), and AND (2012). The CDC (2013) states that only 76.5 percent of infants had ever been breastfed in 2013. Parenting stress, the perceived stress that comes from being a parent may affect how parents feed their infants and may ultimately affect their children's diet diversity. The aim of this research study was to examine the relationship between diet diversity and infant growth as measured by length z-scores, BMI z-scores, and head circumference z-scores. The second aim was to examine the relationship between diet diversity and parenting stress.

Descriptive statistics were utilized to provide diet diversity information and correlations were performed to determine the relationship between diet diversity and the anthropometric measurements as well as diet diversity and parenting stress. Although none of these correlations showed significant relationships, some important information was found. Even in this low-risk population with approximately 65 percent of mothers having a college degree or higher and a generally low level of parenting stress, less than ten percent of infants who were receiving formula were receiving an iron-fortified formula, and less than ten percent of infants were receiving an iron or vitamin D supplement at six and nine months. Not only was the iron and vitamin D intake low, but the introduction of solid foods was somewhat alarming as well. At the six-month visit, 19 infants were still not receiving solid foods and five infants were still not receiving them at the nine-month visit. Along with the late introduction of solid foods, were somewhat low diet diversity scores, especially at nine months. Over 35 percent of infants were not receiving a minimum diet diversity score defined as having a diet diversity score lower than four.

Discussion

Vitamin D and iron supplementation is recommended to breastfeeding infants for the prevention of developmental problems such as rickets as well as motor and mental developmental delays associated with iron deficiency (Wagner & Greer, 2008; Johnson, 2010) The AAP recommends vitamin D supplementation of 400 IU (Wagner & Greer, 2008) and one milligram per kilogram of bodyweight per day for iron until iron-fortified cereals are introduced (Johnson, 2010).

Although blood was not drawn from the infants in the current study, it could be expected these infants would have lower levels of serum vitamin D and iron levels because of the supplementation results. Only 11 infants were receiving a vitamin D supplement at six months of age, and this decreased to nine infants receiving vitamin D at nine months of age. The number of infants receiving an iron supplement or multivitamin was even fewer, just four infants at six months of age and three at nine months of age. These numbers, in combination with less than ten percent of infants receiving iron-fortified formula along with 36 infants being introduced to solid foods at six months or later could lead to a possible vitamin D or iron deficiency.

WHO (2010) has recommendations for minimum diet diversity and minimum meal frequency for infants six to 23 months of age. At six months of age less than ten percent of infants had a diet diversity score of four, most likely due to just beginning the introduction of solid foods, but at nine months a third of these infants still failed to meet this goal. The minimum meal frequency for infants six to eight months is two to three meals (of solid foods) per day. At six months of age only 23 of the infants were meeting this recommendation. At nine months of age the WHO recommendation increases to three to four times per day, and at the nine-month visit only 43 infants were being fed enough to follow this recommendation.

The current study is more similar to the 2002 FITS research study because of the use of food groups compared to the 2008 FITS study using macronutrient and micronutrient intakes (Fox, Pac, Devaney & Jankowski, 2004; Butte, Fox, Briefe, Siega-Riz, Dwyer, Deming & Reidy, 2010). While there are some similarities between the current study and the FITS 2002 study, a major difference was that only 40 percent of infants in the FITS study were receiving at least some breast milk at four to six months of age, while all infants in the current study were. This is due to the population selected for the current study. In 2002, the researchers of FITS determined only about 66 percent of infants were receiving food from the grains food group (Fox, Pac, Devaney, & Jankowski, 2004) whereas over 75 percent of the infants from the current study were receiving grains at six months. Vegetable intake was somewhat similar with approximately 20 percent of infants in both groups not receiving vegetables at nine months. There were differences in the fruit consumption of the two studies, with over 80 percent of infants receiving fruits at nine months in the current study, and only 75 percent of infants ages seven to 18 months receiving fruits in the 2002 FITS study. However, this difference may be because in the current study infant juices and regular juices were included in the fruit group, and in the FITS study juices were a separate category. Overall, the results of the current study compared to the 2002 FITS study are very similar, excluding the breast milk consumption.

A study conducted in Kenya in 1998 showed that infants who were fully weaned from breastfeeding at 12 months had significantly greater diet diversity than those who were only partially weaned (Onyango, Koski, & Tucker, 1998). They also found that diet diversity was consistently and positively associated with height-for-age, weight-for-age, and weight-for-height. While diet diversity was not significantly correlated with anthropometric measurements in the current study there may be a few factors related to the differences in results between these two studies. The first factor that may cause differences in the results is the age difference in the infants when each study was conducted. The Kenyan study evaluated infants 12 to 36 months of age, while the current study evaluated infants at six and nine months of age. The diet diversity of an infant at six months, when they are just beginning to consume solid foods would be much lower compared to the diet of an infant at 12 to 36 months of age who has had more time for exposure to new foods. Secondly, the diet diversity scores in the Kenyan study were calculated from three 24-hour recalls, while the current study was calculated by how many food groups the infants had been exposed to up to that point in their life. For younger infants, it would not be logical to see what types of solid foods they have in a 24-hour period because their diet is still not solely based off of solids. Due to the differences in how the diet diversity score was calculated the scores of the current study may not be indicative of the daily intake as they were in the Kenyan study.

In a 2009 study, stress was one of the top indicators of duration of breastfeeding (O'Brien et al., 2009). Those parents who had higher stress levels were less likely to breastfeed their infants for the recommended four to six months. In 2011, researchers then examined the relationship between parents' perception of their children's level of difficult behavior and the timing of introducing solid foods (Wasser, Bentley, Borja, Goldman, Thompson, Slining, & Adair, 2011). They found that infants with higher scores of activity levels and distress to certain situations were more likely to be introduced to solid foods earlier than four months of age, possibly to use food as a distraction for these infants. Even though these difficult infants were being introduced to solids before four months, this would not necessarily benefit their diet diversity scores, especially if they were only being fed food from one food group.

Hypotheses

The first hypothesis that was examined was diet diversity and infant growth as measured by length-for-age z-scores, BMI-for-age z-scores, and head circumference-for-age z-scores will be positively correlated at both six and nine months. At six months of age the *p* value of the diet diversity and length/height z-score, BMI-for-age z-score, and head circumference-for-age-z-score were all greater than 0.05 at 0.59, 0.39, and 0.60 respectively. The results were similar at nine months with the *p* value of the diet diversity and length/height z-score, BMI-for-age z-score, and head circumference-for-age-z-score were all greater than 0.05 at 0.36, 0.50, and 0.52, respectively, therefore failing to reject the null hypothesis. The second hypothesis that was examined was parenting stress and diet diversity will be correlated at both six and nine months. At six months of age the R^2 ranged from 0.006889 from the difficult child correlation to 0.0001 from the parental distress correlation. The results were similar at nine months of age, the R^2 ranged from 0.0081 from the length/height-for-age correlation to 0.000016 from the parental distress correlation. As R^2 shows the percent of variance in diet diversity attributable to the specific factors, the R^2 values were trivial, therefore failing to reject the null hypothesis.

Limitations

A possible limitation of the study may be the way diet diversity scores were calculated for these young infants. Instead, using a method similar to the FITS 2008 study could provide information about what area of the diet is lacking by comparing specific macronutrients and micronutrients to anthropometric measurements. A second limitation of the study was that much of the dietary information was self-reported, which leaves room for human error. The infant dietary questions were filled out at the six and nine month visit, and while some mothers may have taken notes about the infants diet for the previous months, others may have forgotten details about when they began introducing certain foods. For example, at the six-month visit 75 infants were introduced to solids at the age of four to five months, but for that same question, at the nine-month visit it was reported that only 47 infants were introduced to solids at four to five months. This difference may be attributed to a lapse in memory. At the six-month visit, it was fresh on the mother’s mind because they had just started introducing solids, but at the nine-month visit it may be too hard to recall the previous three months.

A major limitation affecting the results of diet diversity and parenting stress correlations could be that the mothers only filled out the Parenting Stress Index at the initial three-month visit. Therefore the results of the index may have increased or decreased by six and nine months. It may have been more beneficial to look at a six month parenting stress index score compared to six month diet diversity score, and a nine month parenting stress index score compared to a nine month diet diversity score.

Implications for Practice

Although the correlations between diet diversity and the anthropometric measurements were not statistically significant, the research provided some information important for public health. Approximately 50 percent of the families had an income greater than 40,000 dollars and more than 60 percent of the mothers had a college degree or higher. Also, the mother’s were invested enough in their infants’ health and nutrition that they made the effort to predominantly breastfeed for the first four to six months of their infants’ lives. Even with the maternal education level and dedication to breastfeeding in the sample, it was discovered that infants are not meeting recommendations for infant nutrition. Iron and vitamin D supplementation was low, introduction of solids was late for more than 15 percent of the population, and approximately 20 percent of infants had not been introduced to fruits, while another 20 percent had not been introduced to vegetables at nine months of age. As seen previously, the results of the current study compared to the FITS 2002 were very similar (Fox, Pac, Devaney, & Jankowski, 2004). Unfortunately, it has been 12 years and no major improvements have been made in infants' eating habits. As dietitians, it is important to promote recommendations for breastfeeding and complementary feeding and close the knowledge gap about infant nutrition. Mothers hear about the importance of breastfeeding in the hospital and possibly from pediatricians, but for the mothers and families who do not participate in government agencies such as The Special Supplemental Nutrition Program for Women, Infant, and Children, they may not ever hear about the supplement recommendations for exclusively breastfed infants or recommendations on when to begin solids and how to introduce new foods to infants. This information needs to be more publicly assessable either from handouts at the pediatrician's office or blogs that are reader friendly for parents.

Further Research

While diet diversity scores are an excellent way to see an overview of infant feeding habits and nutrition, the scores do not correlate with infant growth seen in anthropometric measurements. Instead, it would be beneficial to look at the micronutrient intake of infants and their serum values to see the correlation between growth and micronutrients such as vitamin D and iron. Although this may be intrusive in infants, it would be helpful in examining the importance of these supplements to infant growth. Secondly, an analysis detailing the information mothers receive about breastfeeding nutrition, complementary feedings, and infant nutrition in general may be important to educate mothers. Standardizing a method to educate mothers such as a flyer that every doctor is required to explain covering this information may increase awareness and increase the amount of infants receiving adequate nutrition.

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APPENDICES

1. Dietary Intake Instructions

To find out how much your child is eating, we would like you to weigh your child before and after each feeding over a 24-hour period.

Please remember to:

- Record the time each feeding begins and ends.
- Weight the child in the same clothes or blankets each time.
- DO NOT change diapers.
- Make sure the scale is zeroed before weighing.
- Write down all 4 numbers in the weight,

If you give you child any additional food or liquids beside breast milk, please **WRITE THESE ITEMS DOWN AS WELL**

For Bottle Feeding: include all liquids and or solids given in a bottle

For Solid Food: write down the type of food including the brand name. Saving labels for us is a good idea.

Call **405-744-5965** with any questions

2. Dietary Intake Record

Subject Number: ___________________________________ Today's Date: ___________

Today's intake was: ___typical ___more than usual ___less than usual

Day of Week: Su M T W TH F Sa

Time	Food	Description	Weight before meal	Weight after meal	Comments

3. Infant Dietary Questions

Questions for 6 and 9 month visit: to be asked by interviewer.

Are you exclusively breastfeeding? Yes No

What kind of formula (or milk) do you use? ________________________

Note to interviewer: make sure to check if the formula is iron fortified or not

How often do you generally give formula? ______________________

How much formula does *(name)* generally take at a feeding? ________________________

When did *(name)* start taking solid food like cereal? ________________________months

What kinds of foods does *(name)* take now?

Note to interviewer: check all that apply

___ baby cereal ___ mashed table food

___ infant fruit ___ cereal: example cheerios/oatmeal (not infant)

___ infant vegetables ___ regular juice/ juice drinks

___ baby meat ___ cow's milk

___ whole ___ 1 or 2%

___ infant "dinners"

___ infant juice

___ infant deserts

___ other homemade puree/ground baby food

___ other foods: ______________________________

When did you start giving *(name)* pureed meat, infant dinners or other meat products?

__________months of age.

How many times a day does *(name)* eat these foods? __________________

Do you give *(name)* any supplements or medications routinely? ________

Note to interviewer: if yes please list all.

Oklahoma State University Institutional Review Board

Date:	Tuesday, December 11, 2007
IRB Application No	AS0783
Proposal Title:	Maternal Dietary Nutrients and Neurotoxins in Infant Cognitive Development

Reviewed and Processed as:	Expedited (Spec Pop)

Status Recommended by Reviewer(s): Approved Protocol Expires: 12/10/2008

Principal Investigator(s

David Thomas	Tay Seacord Kennedy
215 N. Murray	312 HES
Stillwater, OK 74078	Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval.
2. Submit a request for continuation if the study extends beyond the approval period of one calendar year. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of this research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Beth McTernan in 219 Cordell North (phone: 405-744-5700, beth.mcternan@okstate.edu).

Sincerely,

Sue C Jacobs

Sue C. Jacobs, Chair
Institutional Review Board

VITA

Natalie Marie Iannazzo

Candidate for the Degree of

Master of Science

Thesis: DIET DIVERSITY WHILE INTRODUCING SOLIDS TO BREASTFED INFANTS AND THE EFFECT ON THEIR GROWTH

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